VOLUME III
DRAWING MANAGEMENT AND DRAFTING STANDARDS HANDBOOK
Part 2 - Drafting Standards

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Section I. GENERAL INSTRUCTIONS

1. **Scope and Purpose**. This handbook provides the procedures for preparing electronic drawing files, figures, maps and associated Computer-Aided Design (CAD) products within the Bureau of Reclamation. These drafting standards are for the purpose of standardizing the preparation of drawings, simplifying various details of work, and securing the greatest possible uniformity in appearance, size, and style consistent with the subjects and purpose involved. All work shall be done in conformity with these guidelines, and with those contained in the United States National CAD Standard (NCS).

2. **General Drafting Requirements**. Since a drawing or a map is a means of conveying and recording information, the information shall not only be correct, but arranged and referenced making the drawing or map easily and clearly interpreted. Construction drawings shall be completed in a manner so that the use of scales or reference to the specifications is not needed to determine sizes or dimensions. Finished drawings shall be prepared so that electronic versions, contact prints, and reductions to smaller scales commonly in use will be clear and legible. Careful consideration shall be given to lineweights, and to accuracy, style, size, and position of all notations.

3. **Policy**. All engineering drawings created or accepted by officials, employees, or contractors for Reclamation are the property of the Federal Government and are not transferable with the feature/structure. The Information Management Handbook Volume III *Drawing Management and Drafting Standards*, Part 1 – Drawing Management Administrative Procedures (IMH–III, DM) contains official guidelines for the creation, maintenance, and retention of engineering drawings.

4. **Operation**. Operational activities provided by Drawing Managers (regardless of organizational location) shall be centralized and closely coordinated with the engineering and drafting staff. For the most effective operation, all drawings must be numbered, indexed, filed, and managed by Drawing Managers regardless of format or media. The electronic drawing files and official record drawings shall be stored in the Electronic Drawing Repository and Automated Workflow Solution (eDRAWS).

5. **Simplicity**. All unnecessary work, such as the duplication of views and notes, unnecessary details and excessive decoration in borders, lettering north points, meridians, and other features, shall be avoided. The CAD software shall be allowed to guide the user in creation of accurate and simple drawings. Simplicity shall be practiced in every detail and notes shall be limited to those required for accurate interpretation.

6. **Media**. All drawings are to be stored electronically in eDRAWS as a digital image of the original signed drawing and/or the electronic drawing file.

Section II. PREPARATION OF DRAWINGS

1. **Drawing Layout**. Drawings shall be prepared in accordance with the following principles where applicable:

   A. General Maps. General maps, vicinity maps, aerial photographs and all similar maps shall be oriented with North to the top of the page. If North cannot be shown toward the top, it shall preferably be toward the left side of the map. See *figure 11* for Standard North Arrows.

   The long dimension of the map shall be preferably from the left to right (landscape), rather than from top to bottom (portrait). All legal subdivisions or coordinate lines shall be referred to fixed and readily identifiable points, such as section or quarter section corners.

   B. Location Maps. Location maps which are included in project planning reports, environmental statements, design data, or specifications shall clearly identify the location of the project. Suggested additional information may include the county or counties in which the feature is located, township and range lines, and when necessary for clarity, a highway direction arrow showing mileage from the closest key town to the nearest important town or city if outside the map area.

   Orient the drawing so that North is pointing to the top of the sheet. See *figure 18* for Location Map Standards.

   C. General Plan or Layout Drawings. Detail maps, plans and layout drawings for dams, reservoirs, and most other major structures shall be oriented so that the streamflow direction is from bottom to top or from left to right on the drawing. The general rule for streamflow orientation shall be in accordance with *figure 25*. Powerplant structures and irrigation drains are the exception.

   Streamflow direction for powerplant structures shall be from top to bottom or from left to right on the drawing. The orientation of powerplant structure drawings shall be in accordance with *figure 26*.

   Streamflow direction for irrigation drains shall be from top to bottom or from right to left on the drawing. The orientation of irrigation drain drawings shall be in accordance with *figure 26*.

   A streamflow arrow shall be shown indicating the direction of flow. A North arrow shall be included wherever applicable. When match lines are used, state plane coordinates shall be on the plan to the inside of the match line. State plane coordinate labels shall be placed as close to the inside of the drawing border as

possible to make them clearly visible.

D. **Elevations, Vertical and Horizontal Sections**. All sections and elevations paralleling the direction of streamflow shall be drawn with the direction of flow from left to right. Except for plant structures, vertical sections and elevations normal to the directions of flow of a stream or canal shall be looking downstream, unless such arrangement would fail to show the feature intended by the section.

E. **Reference Lines and Stationing**. Except for drains, reference lines on structures paralleling the streamflow shall be stationed downstream in the direction of flow, and reference lines shall be stationed from right to left so that sections normal to such lines will be oriented with water flowing from left to right.

F. **Plan and Profile Stationing**. Stationing shall increase from left to right on plan and profile drawings. For irrigation canals the stationing shall increase downstream, and for drainage canals the stationing shall increase upstream. Railroads and highways shall follow the stationing of existing railroads or highways into which they tie. If they do not tie into any existing railroad or highway, stationing shall be adopted to suit local conditions. In all cases, the abbreviation for the word "station" shall be eliminated. At the left end of the profile, the word "STATION" shall be used once.

See *figures 19 and 20* for Plan and Profile standards.

G. **Aerial Photographs**. When quality aerial photography is available for canal, pipeline or roadway alignments, the regular plan and profile used in specifications shall include the aerial view as part of the drawing.

2. **Drawing Sizes.** Drawing sizes shall conform to NCS requirements.

Whenever possible, figures shall conform to A size sheets and Specification Drawings shall conform to B or D sizes. The use of oversize drawings is discouraged.

See *figure 1* for the standard D size specification drawing and standard sheet border. B size drawings will use the standard D size sheet border scaled at 50%.

3. **Title Blocks**. The standard title block shown on *figure 2* shall be used on all specifications, construction, standard design, and feasibility design drawings and shall be on the right side of each drawing.

Values for lines 3 through 5 below are standardized to expedite document retrieval from eDRAWS.

Regions and offices shall establish standard values to be used when completing title

block line 6 and Area D.

The attributes shown on *figure 2* are to be completed as follows:

Area A:

Line 1: U.S. DEPARTMENT OF THE INTERIOR
Line 2: BUREAU OF RECLAMATION
Line 3: The project name and State(s)
Line 4: The project subdivision (Division only - do not include Unit)
Line 5: Principal feature showing the title, feature name or equipment
Line 6: Subfeature name or equipment

Lines 4 or 6 may be left blank as necessary. When fewer lines are used, do not respace the lines.

Lines 5 and 6 may extend to two lines maximum.

Area B:
The names of the designer, geologist, drafter, checker, technical approver, and admin approver/peer reviewer shall be placed on the indicated lines. The professional designation of the technical approver and peer reviewer will be included immediately following the typed name on the respective lines. The peer reviewer or admin approver's title shall be included below the signature line. See *figures 3 and 4*. O&M Offices may have signature and approval requirements that vary from those shown in ***figure 4***.

Area C:
Show the name of the City and State in which the origination office is located, and a date selected by those responsible for the drawing or series of drawings. The state shall be in the two-character format, separated from the city by a comma. The drawing date shall be in the YYYY-MM-DD format, for example, 2014-03-15 represents the date March 15, 2014.

Area D:
Insert descriptive statements of drawing contents and drawing details. Each statement may extend to three lines maximum.

Area E:
Insert the permanent drawing number, for example 40-D-1776, indicating the project number (40), station number (D), and sequence number (1776) separated by dashes. See Section II.4. Drawing Numbers. This space may be used for temporary numbers, only during the drawing creation and internal review if advantageous, before the assignment of the permanent drawing number.

An alphabetic character at the end of the drawing number shall not be used.

If a drawing is part of a series of two or more drawings, update the sheet number for each together with the total number in the series. For example, SHEET 3 OF 12. The default is SHEET 1 OF 1. **No two sheets will have the same permanent drawing number.**

Area F:
Insert the Specification or Solicitation Number below the title block at the bottom of the sheet. The specification or solicitation number is optional and not part of the drawing.

Area G:
Insert the name and version of the CAD software used to create the drawing. Also insert the filename used to store the drawing. The date and time plotted and plotted by are also inserted.

Area H:
Insert the associated sheet or page number for the drawing above the title block. The page number is optional and not part of the drawing.

4. **Drawing Numbers**. All permanent drawings are numbered in the uniform numbering system as detailed in Part 1 - Drawing Management Administrative Procedures, Chapter 1. The values that constitute the drawing number are listed in Appendix B and C of Part 1. Indexes and records from which drawing number sequences are assigned are maintained as part of the drawing and records file operations. Drawing numbers shall be assigned and managed using eDRAWS.

   eDRAWS uses the drawing number together with the sheet number and revision number as the unique record value. Duplicate drawing numbers are not permissible.

5. **Identification of Overlays**. The use of overlays is generally considered obsolete for new drawings.

6. **Marking Replacement Drawings**. A new drawing that is prepared to supersede a previous drawing shall be marked as follows:

   THIS DRAWING SUPERSEDES DRAWING
   (old drawing number), YYYY-MM-DD

   Place this notation to the left of the title block. The new drawing shall be assigned a new drawing number. Since the act of creating a superseded drawing is a type of revision include the date of the supersedes action.

   The old drawing shall be marked:

THIS DRAWING SUPERSEDED BY DRAWING
(new drawing number), YYYY-MM-DD

Place this notation to the left of the title block with a diagonal line through the title block. If space does not permit, the notation may be placed at a convenient location on the drawing as near to the title block as possible. Include the drawing number that supersedes the old drawing and since the act of creating a superseded drawing is a type of revision include the date of the supersede action. The old drawing with the notation and diagonal line will be saved in eDRAWS as the final revision.

The date used on both the supersedes and superseded drawings shall be the same.

See *figure 7* for additional requirements and an example for marking drawings.

This action does not apply to standard drawings (Project number 40). See Part 1, Chapter 5.

7. **Drawings Designed by Others**. A new drawing that is prepared by a non-Reclamation entity (contractor, manufacturer, etc.) as part of a Reclamation specification will be assigned a permanent drawing number as established by the uniform numbering system.

   This drawing shall be signed by a Reclamation official as "accepted" following the directives and standards contained in the Reclamation Manual (RM) directive *Design Activities* **FAC 03-03**.

   For drawings designed by others that contain both the Reclamation standard title block and the manufacturer/contractor signature lines (See *figure 4*):

   The manufacturer/contractor should add title block information in the manufacturer/contractor title block area.

   Add the word "MANUFACTURER" or "CONTRACTOR" on the DRAWN signature line.

   The drawing shall be digitally signed as accepted (not technically approved) by the Reclamation accepting official on the ACCEPTED line in eDRAWS. The signatory's professional designation is automatically added by eDRAWS after the signature.

   For drawings designed by others that do not contain the Reclamation standard title block or contain the standard title block but without the manufacturer/contractor signature lines (See *figure 4*)**:**

   The designed by others acceptance block and a permanent Reclamation drawing number must be added to the drawing before the drawing can be "accepted" by Reclamation. eDRAWS will add the name and professional designation of the

Reclamation accepting official inside of the block following acceptance.

The designed by others acceptance block shall show the date, name and professional abbreviation (if applicable) of the Reclamation official accepting the drawing; the manufacturer/contractor name, original drawing number and date; and the Reclamation solicitation/specification number and/or the contract number.

Drawings designed by others with a non-Reclamation standard title block shall include the manufacturer/contractor acceptance block and permanent Reclamation drawing number placed in the lower right hand corner of the drawing where space permits.

Drawings designed by others with a Reclamation standard title block but without the manufacturer/contractor signature lines shall include the completed manufacturer/contractor acceptance block in the manufacturer/contractor title block area.

To revise or as-built the drawing, the original manufacturer/contractor title block shall be removed and replaced with the Reclamation standard sheet border and title block. The name of the Reclamation accepting official who signed the designed by others acceptance block will be placed on the accepted line in the signature area. The designed by others acceptance block will stay on the drawing but will be moved to the manufacturer/contractor title block area (see *figure 4*). Complete the revision or as-built the drawing by following the instructions provided in Section II.10. Drawing Revisions.

8. **Information Drawings**. Information drawings are included in many specifications to show existing features, equipment or installations. These drawings are copies of existing official record drawings that have appeared in previous Reclamation specifications. Information only and existing installation drawings shall be created from a quality reproduction of the original specification drawing and marked as indicated in *figure 6*. The original drawing is not to be modified.

9. **Signatory Approval**. Signatory approval is required for specifications, construction, standard design, and feasibility drawings (See *figure 3*). Signatory approval for drawings shall follow the directives and standards contained in the Reclamation Manual (RM) directive *Design Activities* **FAC 03-03**. Preliminary planning sketches, diagrams, and other classes of sketches and diagrams may be signed as determined by the operating office head and may not require signature by a registered engineer or architect.

   The design team leader (or group manager) is responsible for ensuring that proper technical reviews and peer reviews are performed, that the personnel performing these reviews are technically qualified, and the digital approval process is completed in eDRAWS.

10. Revisions to Signed Drawings. Revisions to official record drawings shall be indicated as shown on *figure 5*.

Revisions shall only be made to finished drawings that have completed all signature requirements. Each revision will be consecutively numbered. This will assist in identifying the most recent version. These numbers will be assigned at the time of the revision; however, when revising a drawing where no previous revision numbers have been used, the Drawing Manager will assign a revision number based on the drawing history file.

Revision blocks shall show the date, station, name and professional designation of the person technically approving the revision, and a brief description of the drawing revisions. The technical approval process will be completed in eDRAWS.

Drawings are the responsibility of the office identified by the station number. Revisions to a drawing created by one office shall not be made by another office without written approval from the originating office. When responsibility for a drawing is assumed by a station other than the original, it is recommended that the original drawing be designated "superseded" and a "supersedes" drawing be created (See Section II.6. Marking Replacement Drawings).

When a new drawing is created, which partially modifies the design shown on an existing drawing or drawings, the new drawing shall identify the existing drawing(s) it modifies. The existing drawing(s), where possible, shall be revised by the originating office to show the latest configuration or, as a minimum; have a note added describing the revisions and the drawing number of the new drawing modifying its design.

The design team leader (or group manager) is responsible for ensuring that the proper technical review of the revisions is performed, that the person performing this review is technically qualified and digitally approves the revisions in eDRAWS.

A revision technical approval is a quality control process performed by a person who is involved in the preparation of the drawing revisions and who is technically responsible for the information portrayed. The revision technical approval includes a check of calculations, tests, and methods used to develop the technical information shown in the drawing revisions. The Technical Approver makes sure calculations support design, and is involved throughout the design process. The Technical Approver digitally signs the revision block on the drawing. It is the responsibility of the Technical Approver to ensure that all of the technical information prepared by others and depicted on the drawing revisions is compatible with the overall design intent.

The use of revision clouds or circles is discouraged.

To facilitate revision of original drawing changes or additions, marked prints must be

clear and legible and include such notes as may be necessary. Additions or changes shall be made in red, deletions in green, and reference information in blue.

11. **Drawings Requiring As-Built Revisions**. As-built revisions must be completed in compliance with Chapter 8. As-Built Drawing Process contained in Part 1 – Drawing Management Administrative Procedures of this handbook.

    As-built revisions to drawings shall be indicated as shown in *figure 5*.

    The as-built block shall show the date, station number, and name and professional designation of the person digitally approving the revision (See Section II.10. Drawing Revisions above for qualifications). The as-built station and transmittal letter date (if applicable), specification or solicitation number, and contract number under which the work was completed will be noted in the description of the drawing revisions. A brief description of the drawing revisions is not necessary.

    As-built blocks shall be numbered in the same manner as standard revision blocks, see Section II.10 Drawing Revisions.

    The use of revision clouds or circles is discouraged.

    Every drawing in a contract package that contains technical information about a completed project shall have an as-built revision block added even when no revision needs to be made to the drawing.

    Location and vicinity drawings do not require as-built revisions.

12. **Scales of Drawings**. Scales of drawings will vary with the size and character of the feature or the degree of detail to be shown. Graphic scales are not to be shown on drawings of equipment that is shop fabricated.

    Scales shall be selected with care in order to obtain drawings of approximately uniform size, which convey the information in a clear and unmistakable manner.

    Graphic scales shall be shown on all general and structural drawings and on any drawings where considered necessary as an aid to personnel in the field or the contractor. When it is necessary to use more than one scale on a drawing, show a graphic scale under each view and detail title.

    A. NCS-Architectural Scale. The standard architectural scales are generally used for drawings of buildings and other large structures that can be represented on a standard size sheet only to a small scale, frequently to a scale of 1/4-inch equals 1-foot. The scales are divided into major units, from 3 to 3/32 inch, each representing 1 foot and subdivided to represent inches and fractions thereof.

See *figure 8* for standard architectural scales.

B. **NCS-Engineering Scale**. The standard engineering scales are generally used for maps, general plans, profiles and layouts of dams and appurtenant structures, as well as for scientific drawings, graphs, and charts.

The scales are available with divisions of 10, 20, 30, 40, 50, or 60 parts to the inch, and for example can be used to represent scales of 1 inch equals 50 or 500 feet. These scales can also be used to draw stress diagrams to scales of 1 inch equals 20 pounds, 1 inch equals 4,000 pounds, etc.

Scales that cannot be measured using an engineering scale shall be avoided. i.e. 1”=15’, 1”=25”, 1”=35’, etc. For this reason, the use of scale divisions 30 and 50 is discouraged for D size drawings which may be printed half size. The use of scale divisions 40 and 60 is also discouraged for B size drawings which may be printed at double size.

See *figure 8* for standard engineering scales.

C. **NCS-Metric Scale**. Bar scales that show the length measurements in millimeters will not require unit identification: for example, for the 1:100 scale ratio, 1 mm (measured) represents 100 mm (actual). For larger scale ratios, it may be desirable to use an alternative unit: for example, the 1:5 000 000 bar scale may be expressed in meters or kilometers (e.g., 1 mm represents 5000 m, or 1 mm represents 5 km). When millimeter is not the basic unit, add the unit symbol after the numerical unit on the right-hand end of the bar scale.

Refer to *figure 8* for the format of bar scales for the scale ratios between 2:1 and 1:5 000 000 and for placement of metric scales on design drawings.

D. **Exaggerated Scale**. In cases where it is necessary to show the vertical scale differently from the horizontal scale of the view, the elevations shall be clearly shown along the left side of the exaggerated view.

E. **Cartographic Scale**. The standard cartographic scales are generally used for intermediate and small scale maps which portray large map areas. While not defined in the NCS, the cartographic scales are now visually similar.

The scales can be used to represent scales of 1 inch equals 1 mile, 5 miles, 6 miles, 8 miles, or 16 miles.

See *figure 8* for standard cartographic scales.

F. **No Scale** Drawings that are drawn schematically, in 3-D, or with no identifiable scale shall be labeled **"NOT TO SCALE"** in place of the scale in the view title**.**

13. Lettering. Lettering shall generally be in accordance with *figure 10*.

Text on all AutoCAD drawings shall be the standard Leroy and VLeroy style as established by the Reclamation-Wide AutoCAD Steering Committee; text on other non-AutoCAD electronic drawing files shall be Roman Simplex style or similar.

All lettering shall be plain, simple, free from adornment, and readily legible.

14. Capitalization on Drawings. In order to avoid confusion in the capitalization on drawings and to ensure uniform practice, all descriptive statements, notations, explanations, etc., on drawings shall be in accordance with the same English grammatical rules used in writing a letter. No word shall be started with a capital letter unless it begins a sentence, is abbreviated, or is a proper noun.

Exceptions to this rule are the abbreviations used in horizontal and vertical curves, concrete detailing and HVAC system symbols as shown on *figures 25, 27, 37 and 45*. Lettering included in symbols and linework shall be mainly uppercase characters.

Titles and subtitles shall be all uppercase characters.

On plan and profile drawings (See *figure 24*), existing information is depicted in accordance with the above rules. Information for new or proposed features is depicted with all uppercase characters.

15. Notes on Drawings. Notes shall be placed on the right-hand side of the drawing adjacent to the title block. If space does not permit placement of notes to the left of the title block, they may be placed where space permits. All notes shall refer only to the matter which a drawing relates: i.e., design, construction, and materials and shall not provide information normally contained in the project specifications. Where necessary for clarity, notes concerning assembly or erection methods may be included.

In the case of two or more drawings pertaining to a given feature, the notes on the drawings shall be carefully compared to avoid inconsistencies. Notes shall use directive statements such as "Slope all piping 2%" instead of "All piping shall be sloped 2%". Subsequent lines of the same note may be indented two spaces. See *figure 10*.

16. Dimensioning. Dimensioning on drawings shall be in accordance with ANSI Y14.5M, "Dimensioning and Tolerancing" and the NCS. In addition to millimeter and decimal inch dimensioning, fractional inch and decimal foot dimensioning may also be used. Basic principles of dimensioning in accordance with ANSI Y14.5M are shown on *figure 12*.

Decimal foot dimensioning is to be used for dimensioning earthwork, engineering dimensioning is to be used for machined parts, and fractional inch dimensioning is to be used for architectural and structural dimensions as shown in *figure 12*.

Foot and inch marks shall be shown on all drawings using imperial units.

17. **Lineweights and Styles**. Lineweights and style conventions are illustrated on *figure 11*.

18. **Labeling of Views**. Views and cutting planes shown on drawings shall be labeled to clearly identify how the view was developed as shown on *figure13*. Sections shall be labeled alphabetically excluding the letters I, O, and Q. If the alphabet is exhausted, additional sections shall be indicated by double letters such as AA - AA, AB - AB, etc. Details shall be labeled by numbers increasing sequentially from 1.

    The term “Figure” or “View of” shall not be used on any drawings.

Section III. DRAFTING SYMBOLS AND NOTATIONS

1. **General**. Standard symbols and drafting notations shall be used in all cases where they will clarify drawings or facilitate their preparation. The NCS contains additional information on symbols and notation.

2. **Mapping Symbols**. Standard mapping symbols are shown on *figures 18 and 22*.

   Standard geologic symbols are shown on *figures 16, 30, 31 and 32*.

   Standard map symbols for powerplants and transmission lines are shown on *figure 28*.

   Standard symbols for hydrologic maps are shown on *figure 23*.

3. **Material Symbols**. Conventional shading and cross-hatching to represent the cross sections of various metals, minerals, insulation, packing, and other construction and foundation materials are shown on *figure 15*.

   Lithological symbols for geological mapping and profiles or columnar sections are shown on *figures 16 and 32*.

   Conventional representations for various materials are shown on *figure 15*. When showing material symbols for a section, it is not necessary to show the symbol throughout the entire section; provided that the symbol is shown to such an extent to clearly define the area of the cross section. See *figure 17* for examples of symbol placement. All material symbols shall be placed with a very light (.007" / .18mm) lineweight and at a size proportionate to the scale of the drawing.

4. **Mechanical Notations**. The fusion welding symbols are in accordance with the American Welding Society (AWS) Standards. Commonly used welding symbols are shown on *figure 46*.

   Finish marks (surface roughness) shall be in accordance with American National Standards Institute, Inc., ANSI Y14.36M, “Surface Texture Symbols”. Commonly used surface roughness symbols are shown on *figure 47*.

   Fluid power symbols and diagrams shall be in accordance with American National Standards Institute ANSI Y32.10, “Graphic symbols for Fluid Power Diagrams”, and ANSI Y14.17, “Fluid Power Diagrams”.

   Heating, ventilating and air conditioning systems shall be in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) standards as shown on *figure 45*.

Fire protection systems shall be in accordance with ASHRAE standards as shown on *figure 40*.

Examples of mechanical details are shown on *figure 48*.

5. **Structural Notations**. Structural steel and concrete convention notations are shown on *figures 47 and 27*, respectively. See section IV, paragraphs 1, 2, and 3 for special standards and instructions.

6. **Electrical Symbols and Conventions**. Electrical symbols and conventions shall be in accordance with American National Standards Institute C37.2, Electrical Power System Device Function Numbers and American National Standards Institute Y32.2, Graphic Symbols for Electrical and Electronic Diagrams.

   Commonly used symbols and conventions are explained and illustrated on *figures 37, 38 and 39*.

   The conventions for marking terminal blocks, conductors, conduits, and junction boxes shall be adhered to uniformly. In general, the symbol shown for a device shall be used on one-line diagrams and other diagrams where complete internal wiring and location of terminals is not necessary.

   On detailed wiring diagrams, an outline approximating that of the actual device shall be shown with terminals in their actual relative locations and with internal connections represented by standard basic symbols. Each device shall be labeled using the standard designations.

   Switchboard panel wiring diagrams shall be shown with all devices and terminals in approximate relative locations and with internal connections shown if space permits. If internal connections cannot be shown completely on the panel wiring diagram, an internal wiring diagram of the device shall be shown elsewhere. If this diagram is located on a separate drawing, appropriate references to the original drawing shall be included.

   Each device shall be labeled with the standard ANSI device designation. The device designations shall be made larger and heavier than other lettering on the diagram.

7. **Piping Symbols and Conventions**. Piping symbols, conventions and fabrication details for use in preparation of piping drawings are illustrated as listed below:

   Schematic piping symbols are shown in *figure 41*.

   Piping schematics shall be drawn with single lines. Piping layouts for 2-inch diameter or less shall be drawn with single lines. Piping layouts for pipes greater than 2-inch diameter

shall be drawn with double lines. Pipe single and double line drawings are shown in *figure 42*.

Pipe inserts and line symbols are shown in *figure 43*.

Plumbing symbols are shown in *figure 44*.

8. **Architecture and Landscape Architecture Symbols and Conventions**. Line styles and weights, text, symbols, conventions and details for use in preparation of architectural and landscape architecture drawings are illustrated as listed below:

   Architectural line symbols and weights are shown in *figure 11*.

   Lettering and dimensioning is shown in *figures 10 and 12*.

   Building and detailing symbols are shown in *figure 33*.

   Sample architectural drawings are shown in *figures 34, 35 and 36*.

Section IV. SPECIAL STANDARDS AND INSTRUCTIONS

1. **Scope**. Major structures require the preparation and correlation of many drawings. The following paragraphs contain instructions for the preparation of basic structural design drawings; basic structural steel design drawings; lighting installation plans; wiring diagrams for switchboards; preliminary estimate drawings; specifications and construction drawings; and illustrative drawings, maps, and charts. Additional information is contained in the NCS. Conventional notations for various classes of drawings are described in Section III.

2. **Basic Structural Design Drawings**. Structural design drawings can be classified as specification drawings or construction drawings. The specification drawings inform prospective bidders of the nature and complexity of the work so those bidders may arrive at unit prices for the various phases of the work. Construction drawings give the construction contractor complete detailed information necessary for excavation and erection of the structure.

   A. **General Arrangement Drawings**. The general arrangement drawings are specification drawings that show the relationship between the equipment and the structure. The drawings are of a general or typical nature because the equipment to be housed (such as turbines, pumps, generators or motors, transformers, and control equipment) is usually not purchased early enough to show the exact dimensions or sizes.

   B. **Structural Arrangement Drawings**. The structural arrangement drawings are included in the specifications to provide bidders enough information to determine unit prices for the work. All structural members are dimensioned with either final or assumed dimensions; the structural framing is indicated; the major construction, contraction, and expansion joints are shown; major embedded equipment is indicated; and the different classes of concrete are identified.

   C. **Typical Reinforcement Drawings**. Drawings showing typical reinforcement details are included in the specifications to indicate the relative complexity of the reinforcement in various stages and parts of the structure. Included is general information as to splice locations and the general pattern of the reinforcement. The size and spacing of the reinforcement may also be shown.

   D. **Structural Design Data Drawings**. For major reinforced concrete structures, the basic structural design data, including assumed or known loading, foundation and material properties, and design methods and assumptions are summarized on the structural design data drawings. Smaller reinforced concrete structures may have these data listed on one of the other drawings. This information is usually included in the specifications to indicate the magnitude of loading conditions and the various equipment dimensions and weight.

E. **Standard Design Drawings**. Drawings that show typical material and construction details required for the structure are used in the specifications. These drawings represent the Bureau of Reclamation's standard details of construction and cover a magnitude of construction details, such as joints in concrete, waterstops and keys, floor finish at drains and rail blackout, roofing and flashing details, tooled and formed grooves, etc.

F. **Outline Drawings**. The outline drawings are construction drawings and show all dimensions and information necessary for the erection of forms and placement of concrete. All embedded material shall be properly indicated and accurately located or else referenced on the outline drawings. The concrete finishes shall be indicated or referenced to a concrete finish schedule.

G. **Reinforcement Design Drawings**. Reinforcement design drawings are provided to contractors for bidding purposes and for proper fabrication and placement of reinforcement. Major plans and sections for reinforcement drawings generally shall be the same as the major plans and sections used on the outline drawings. The arrangement of views on reinforcement drawings shall also be similar to the arrangement of views on the concrete outline drawings. As a general consideration in preparing a reinforcement design drawing, there shall be no doubt as to the location, size, length, spacing, or shape of any reinforcing bar. Reinforcement shall be shown in at least two views. One view is used to specify the reinforcement spacing and the other to show the true reinforcement shape and length. Reinforcing bar line weights and welded wire fabric shall be chosen so as to emphasize them on the drawing. Detailing of the reinforcement shall follow the requirements of *figure 26* and Standard Drawing 40-D-6263 (General Notes and Requirements for Detailing Reinforcement). Splices, embedments, and hooks shall be clearly shown and drawn to scale.

H. **Excavation Drawings**. For complex building structures, rock and earth excavation drawings are furnished in the construction specifications. These drawings show the required excavation for the structure, establish the pay lines for excavation and refill material.

I. **Other Structural Drawings**. Other structural drawings that may be prepared, depending on necessity and the magnitude of the job are:

1. Stability analyses
2. List of structural drawings
3. Sequence of construction
4. Joint details
5. Miscellaneous building details

3. **Basic Structural Steel Design Drawings**. Basic designs on structural steel work for major

structures, such as plant superstructures, crane runways, and substation structures shall show the design loadings, including crane, roof, conductor, grounding wire, wind and earthquake loads on the "Structural Design Data" drawing. Floor areas constructed of steel, including platforms, floor plates, grating, hatches and covers, shall show the design live load on the structural steel drawing.

4. **Preliminary Estimate Drawings of Dams**. Preliminary estimate drawings of dams shall include:
    1. A general plan of all proposed permanent construction on a detailed topographic map of the site and the area immediately adjacent
    2. Profile on the axis of the dam
    3. Developed upstream elevation
    4. For earthfill dams a developed downstream elevation
    5. Maximum cross section of the dam
    6. Centerline profile section through the spillway
    7. Centerline profile section through the outlet works
    8. Reservoir area and capacity curves
    9. Discharge curves of the spillway and outlet works
    10. General location map
    11. Centerline profile through the waterway and power or pumping plants
    12. Logs of investigational borings available with locations of borings shown on the general plan
    13. A cross section showing the top of the dam in greater detail may be added if space is available.

5. **Location on Drawing**.

    A. General Plan and Sections. The general plan shall be located on the left side or upper left-hand corner of the drawing. The general rule for streamflow direction is from bottom to top or from left to right on the drawing (See *figure 19*). All sections shall be such that the direction of streamflow is from left to right.

    Exceptions to the general rule are: streamflow direction for powerplant structures shall be from top to bottom or from left to right on the drawing and streamflow direction for irrigation drains shall be from top to bottom or from right to left on the drawing (See *figure 29*).

    B. Area and Capacity Curves. The area and capacity curves will be placed to the left of the title block in the upper right-hand corner of the drawing, the area for the curves shall be rectangular in outside dimensions with the height about two-thirds of the width.

    C. Location Map. The general location map shall preferably be located in the upper right-hand side of the drawing next to the area and capacity curves, always with the

north direction at the top of the map.

D. **Exploratory Borings**. Exploratory borings shall be shown on all drawings relative to the feature or purpose of the drawing.

E. **Vicinity Map**. A vicinity map shall be included if necessary to show the location of earth embankment materials or concrete aggregate materials proposed to be used in construction.

F. **Reference Drawings, General Notes, and Legends**. Reference Drawings shall be placed to the left of the title block. General notes shall be placed above reference drawings or to the left of the title block. Legends shall be placed to the left of the title block in the upper right-hand corner of the drawing.

6. **Specification and Construction Drawings**. Specification and construction drawings shall include an aerial photograph of the site and the general plan or layout drawing. These drawings shall show all features and details required in the preliminary estimate drawings, but in greater detail and with greater accuracy depending upon the data available. Plans and horizontal sections of all drawings shall be oriented as described in section II, paragraph 1, subparagraphs C, D, E, and F of these standards unless an exception is definitively warranted.

7. **Illustrative Drawings, Maps, and Charts**. In addition to the types of drawings and maps discussed in the foregoing paragraphs, there is a requirement for a variety of illustrative and pictorial aerial photographs, drawings, charts, and maps.

A. **Illustrative Drawings**. These drawings shall be prepared neat and legible. The main idea shall be clearly presented so the viewer does not need to study the drawing at length. Omit all nonessential details to prevent cluttered appearance. Lettering shall be large enough to be easily read. Borders shall be used only when they improve the appearance of the drawing.

B. **Drawings for Reproduction**. These shall be prepared so they will be uniform, neat, and legible when printed. Nonessential details shall be omitted. Lettering shall not be crowded and must be large enough to allow for reduction. In determining the weights and dimensions of the lines and lettering, take into consideration the amount of reduction and the dimensions of the drawing after printing to ensure legibility, and maintain proportion with the drawing's appearance.

C. **Architectural Drawings**. Architectural drawings and pictorial representations of proposed structures are desirable in selecting the style of structure, its arrangement, and setting. Such drawings are also useful in describing projects at Congressional hearings and to various citizens' and water users' organizations. Standards are shown on *figures 33, 34, 35 and 36*.

D. Perspective Maps. Perspective maps have proved useful in illustrating transmountain diversions and the layout and operation of projects, as well as for their general public relations value.

8. Cadastral Survey Drawings. Standards for the preparation of cadastral survey drawings are shown on *figure 20*.

Section V. PROCEDURES

1. **Post award-transfer of electronic files**. The transfer of all drawings shall be in compliance with the Information Management Handbook Volume III *Drawing Management and Drafting Standards*, Part 1 – Drawing Management Administrative Procedures (IMH–III, DM)**,** Chapter 7.

2. **Check List**. The following check list shall be used to facilitate the completion of the process in compliance with IMH-III, DM, Chapter 7.

POST AWARD TRANSFER OF ELECTRONIC DRAWING FILES
CHECK LIST

Design Office Group Responsibilities (CAD):

1. Verify each electronic drawing file is the latest signed revision.
2. Clear all unused layers
3. Purge all
4. Sanitize drawing as per Chapter 7, Section 5.B.
5. Saveas; Reclamation drawing number with FC at the end, i.e., xxx-xxx-xxxFC .dwg (FC signifies field copy).
6. E-transmit
7. Copy files to common directory, include "List of Drawings", a "Readme" file (.txt), and .exe files.

Reclamation Drawing Manager Responsibilities:

Create CD or DVD discs and Visual Identity Program (VIP) compliant label with the following:

Project Title
Date
AutoCAD Version
Spot check for accuracy of the enclosures
Retain file copy as part of the official record

Enclosures include:

For requesting entity: 1 set of CD/DVD disc(s) and a copy of the "List of Drawings".
For Contracting Officer: 1 set of CD/DVD disc(s) and a copy of the "List of Drawings".
For files: 1 set of CD/DVD disc(s) and a copy of the "List of Drawings".

VOLUME III
DRAWING MANAGEMENT & DRAFTING STANDARDS HANDBOOK
Part 2 - Drafting Standards

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